SECTION 3

TECHNICAL ANALYSIS

3.1 INTRODUCTION

The purpose of this section is to review the management of the green waste stream from both residential and commercial sources. Residential green waste is identified as *City green waste* and commercially collected green waste is identified as *commercial green waste*.

This section discusses broad policy and management options for the City to consider. It is important to note that the City has already implemented many of these options or has expressed its intention to implement them. The options are summarized here to put the existing City programs into the context of the programs that have been used in other jurisdictions. Many of the options we have identified work well in other jurisdictions, but may not be as effective in the City. They are included to provide a basis for discussing hybrid options that might be ideal for the City's situation.

This section discusses green waste quantities from both residential and commercial sources, collection frequencies from residential sources, and the cost of collection from residential sources. The Cost Model prepared as part of this report allows the user to evaluate cost of collection and processing of the residential green waste collected by the City.

The alternatives evaluated in this section have been divided into four categories:

- Policy Options
- Collection Options
- Processing Options
- Marketing Options

After the discussion of each Option, this report will make recommendations for future programs.

3.1.1 Existing Programs

The City has had bans on commercial loads of green waste at City disposal facilities since 1994. The City has not instituted a complete landfill ban of green waste. Instead, the City restricted loads with significant amounts of green wastes. Ordinance No. 89-113, Mandatory Recycling, provided for restricted disposal of commercial green wastes at all City disposal facilities. Commercial trucks, including private refuse haulers, professional tree trimmers, yard maintenance

companies, and government agency trucks were not permitted to dispose of loads containing 50 percent or more green wastes. Since then, the City further reduced the acceptable amount of green wastes to 25 percent. As of 1997, the restriction was changed to no more than 10 percent.

The City has a de facto tipping fee incentive program to encourage source separation. The private composting companies set their tipping fees to compete with the relatively high disposal costs at the Waimanalo Gulch Landfill and at H–POWER .

The City is studying the use of weekly collection of refuse, rather than the twice per week collection service currently offered. That change, with the transition to automated collection for most routes, would support the type of changes described below.

3.2 POLICY OPTIONS

The Policy Options presented are basic public policy discussion points that are considered in many communities that implement new green waste collection programs or modify existing ones. The Policy Options are:

- Mandatory Separation of Green Waste
- Green Waste Landfill Disposal Bans
- Tipping Fee Incentives to Encourage Source Separation
- Collection Rate Adjustments to Encourage Source Separation

An overview of these Policy Options is provided in **Table 3-1**, Comparison of Policy Options.

Skumatz Economic Research Associates (SERA) prepared a nationwide study identifying factors that have a significant effect on green waste diversion in July 1996 titled "Nationwide Diversion Rate Study, Quantitative Effects of Program Choices on Recycling and Green Waste Diversion: Beyond Case Studies." Information in the SERA Report was used in developing and analyzing the policy options.

3.2.1 Mandatory Separation of Green Waste

A mandatory green waste separation program would require householders to separate the green waste for collection. It would result in a major change to the existing program where green materials are collected source separated once per month. Mandatory separation of the material will increase the amount of material being collected, assuming that the monthly collection is not capturing all of the waste. Given the 24 to 35 percent green waste in the disposed waste stream, it is likely that much of the green waste is not being collected in the existing monthly program.

Table 3-1
Policy Options

TYPICAL EVALUATION CRITERIA	OPTION 1 Mandatory Separation of Green Waste	OPTION 2 Tipping Fee Incentive to Encourage Source Separation	OPTION 3 Green Waste Disposal Ban at Landfill	OPTION 4 Collection Rate Adjustment to Encourage Source Separation of Green Waste
1. Reduction Effectiveness	Requires diversion of compostable materials and increases diversion potential.	Effective, provided alternate processing available.	Significantly effective in reducing disposal of material.	Not as effective as mandated measures but can still lead to an increase in capture of clean loads of compostables.
2. Hazard Created	May lead to illegal dumping or burning. May entail extra collections which would increase truck traffic and risk of traffic accidents.	No risk is associated with tipping fee incentives.	Would encourage illegal dumping and illegal burning of yard waste.	No significant risk is associated with collection rate incentives.
3. Ability to Accommodate Changing Economic, Technological and Social Conditions	Dependent on a pro-environmental attitude. May be resisted due to inconvenience. Public priorities may change and participation may decline.	Adaptable.	Once banned completely, this alternative cannot be increased.	Dependent on a pro-environmental attitude. May be resisted due to inconvenience. Collection rate incentives can be modified to adapt to a wide range of conditions.
4. Potential Change in Waste	Could encourage the generation of bags used to contain green waste products.	Reduction of disposed green waste.	Reduction of disposed green waste.	Reduction of disposed green waste.

TYPICAL EVALUATION CRITERIA	OPTION 1 Mandatory Separation of Green Waste	OPTION 2 Tipping Fee Incentive to Encourage Source Separation	OPTION 3 Green Waste Disposal Ban at Landfill	OPTION 4 Collection Rate Adjustment to Encourage Source Separation of Green Waste
5. Ease of Implementation	Likely to encounter public opposition.	Alternative currently implemented at private composting facilities.	Waste restrictions currently underway.	Generally accepted by the public, if there is pre-existing fee structure. May encounter institutional barriers, such as difficulty getting approval of the governing body.
6. Facility Need	None	None	Will require processing facilities off-site.	None
7. Advantages and Disadvantages of Public vs. Private Ownership or Operation	Under public control.	Public or private landfill operator could implement based on public regulation.	Public or private landfill operator could implement based on public regulation.	Private sector may offer collection rate incentives to their customers for commercial green wastes.
8. Consistency with Local Plans & Ordinances	Public policy favors voluntary action. A public ordinance would need to pass.	Consistent with current activity.	Consistent with green waste restrictions at disposal facilities.	Local government could require that a private operator establish collection fee incentives.
9. Institutional Barriers to Implementation	May face political resistance and may be hard to enforce.	None	Consistent with green waste restrictions at disposal facilities.	Considered an acceptable incentive for voluntary action.
10. Cost in Short- and Medium-Term	$100/ton or more.	Incentive cost difference of approximately $20/ton in operator revenue.	Revenue loss at disposal facility.	$20/ton incentives may be necessary to encourage source separation.
11. Potential for Private Sector Participation	Opportunities for private vendors to participate.	Opportunities for private vendors to participate.	Opportunities for private vendors to participate.	Opportunities for private vendors to participate.

This program would be expected to increase the diversion of green waste. It would enhance collection of clean green waste and thus the marketability of compost products. This program is expected to be more effective in capturing clean loads of green waste than less stringent measures.

No significant risk is associated with mandatory source separation. The success of mandatory source separation is dependent upon pro-environment attitudes of the community and the education and enforcement measures employed by the City.

Mandatory source separation could be implemented by passing a local ordinance. Decision-makers are wary of imposing measures that might be perceived by the public as being heavy-handed. Mandatory source separation may face political resistance and may be hard to enforce. Without current City policies requiring mandatory source separation, public policy might favor voluntary action rather than this mandatory program.

SERA determined that making green waste programs mandatory increased diversion by an additional 5-6-percentage points in mandatory green waste collection programs.

> **Recommendation:** As the expanded green waste collection program is implemented, the City should institute a benchmarking program to gauge the amount of green waste that is recovered in each collection district. Should the City not be satisfied with the amount of green waste collected, the City should consider mandatory source separation of green waste.

3.2.2 Yard Waste Landfill Disposal Restrictions

Green waste would be incrementally restricted from disposal at the landfill and H–POWER. Green wastes would be directed to processing sites. The City has instituted a ban on commercial green waste in amounts greater than 10 percent of the load at its disposal facilities. The waste sort currently being competed shows that 13.7 percent of the commercial waste and 28.8 percent of the residential waste going to H–POWER is green waste. Considering the total waste stream, the percentage green is 21.3 percent.

Landfill disposal bans require diversion of compostable materials and boost recycling levels. They are a simple and easily understood policy alternative that would work under a wide range of conditions. No significant risk is associated with disposal bans, although there may be increased chances of illegal dumping or on-site burning in rural regions. Landfill disposal bans are established by a public entity, which will ensure fairness in enforcement of the ban. Commercial haulers might offer reduced rates for source separated materials to go directly to a composting facility and bypass the disposal facilities.

Landfill disposal bans could encounter stiff public opposition if aggressively implemented without advance warning.

> **Recommendation:** The City should consider a systematic enforcement program for the green waste restriction if significant amounts of green waste are disposed of at the landfill or H–POWER.

3.2.3 Tip Fee Incentive to Encourage Source Separation

Under this policy, the tip fee at the disposal sites is set to be greater than the fee at the composting or processing site. On Oahu, the private processors have established fees significantly lower than the tip fee at the City's disposal facilities. The current tip fee at the landfill and H–POWER is $65.75 per ton (scheduled to increase to $72.25 in July 1999). The two composting facilities are currently charging $32 and $40 per ton for commercial wastes. With the differential in pricing between disposal and the composting facilities, they have been experiencing a moderate and consistent flow of green waste.

No significant risk is associated with tipping fee incentives. They are expected to increase the effectiveness of separate green waste drop-offs at the satellite locations and at the processing sites. Tipping fee incentives are generally acceptable to the public.

Tip fee incentives have been perceived as an acceptable incentive for voluntary action. Tip rate incentives will enhance collection of clean materials and thus the marketability of compost products.

The SERA results agree that communities with disposal fees higher than processing fees tend to have higher green waste diversion rates. No quantitative estimate for additional diversion was provided.

> **Recommendation:** In the future, the City should consider the processing fees when establishing its disposal fees so the cost of disposal continues to exceed the cost of processing.

3.2.4 Collection Rate Adjustments to Encourage Source Separation of Green Waste

This method involves the City collecting a differential fee for rubbish and for green waste collection. The City does not currently charge the householder directly for waste collection or disposal services. The cost of the service is part of the property taxes. To use this policy option, the City would have to establish fees for residential waste collection and disposal. Under that approach to financing the solid waste system, the fees charged to the householder could be structured to encourage source separation of green waste (and other recyclables). The financial mechanisms include unit pricing, pay-by-the-pound, and collection rate adjustments. The

commercial collectors could adjust their collection rates to encourage source separation of green wastes.

No significant risk is associated with collection rate incentives, *if user fees for rubbish collection and disposal have already been established in the community*. In communities without collection fees, significant public opposition can be expected when the concept of such fees is introduced.

Collection rate incentives can be modified to adapt to a wide range of conditions. Collection fee incentives are generally acceptable to the public, if they have been paying fees directly for waste collection. Since the City does not collect fees directly, instituting new fees will probably be costly and time consuming.

The public could perceive collection rate incentives as an acceptable incentive for voluntary action to increase recycling. Collection rate incentives will enhance collection of clean materials and thus the marketability of compost products.

SERA determined that variable rate programs increased green waste diversion by 4-5 percentage points on average. The estimate was based primarily upon residential programs.

> **Recommendation:** If the City implements a user fee for rubbish collection and disposal, it should add a rate incentive to participate in the green waste collection program. Any fee incentive will need to include funding for education and procedures to enforce the separation of clean green waste by those householders that receive the lower rates.

3.3 COLLECTION METHODS

This section provides a broad discussion of methods to collect green waste. The options presented, except for curbside collection, would apply to both residential and commercial green waste. The cost of collection varies with frequency of collection and amount of material to collect.

Following are the collection options discussed in this section:

- Separate satellite drop-offs at regional facilities
- Supervised satellite drop-off facilities
- Unsupervised neighborhood satellite drop-off facilities
- Curbside collection

An overview of these Collection Options in provided in a matrix in **Table 3-2**, Comparison of Collection Alternatives.

3.3.1 Separate Satellite Drop–Off at Existing Regional Facilities

Separate tipping areas for green waste could be established at existing regional facilities such as the Waimanalo Gulch Landfill, the transfer stations, closed landfills, H–POWER, and the composting facilities. Regional facilities do not include convenience centers, which already act as satellite drop–off sites. Separate green waste satellite drop-offs at these existing regional facilities are fairly effective measures for obtaining clean loads of materials and increasing diversion rates.

Separate satellite drop-offs may interfere with operations unless there is adequate space to conduct such activity. Typically, City and County facilities do not have space available for green waste drop-off. A 3- to 5-acre site is needed to establish a green waste drop-off program for a 100-ton-per-day facility. The top of the closed portions of a landfill could be used for drop-off green waste collection, if available. Separate drop-offs at landfills and transfer stations would probably be effective, especially with the existing tip fee incentive for the commercial material. However, space constraints will likely prevent establishing drop-off sites at the landfill and transfer stations.

Separate drop-offs should cause no change in waste generation, requires relatively moderate capital costs, and can be rapidly implemented. Assuming that space is available, separate drop-offs would require only a minimal site reorientation (e.g., change in layout and perhaps some paving and fencing). To be most useful, the satellite facility should be located near the downtown area, which would require that the material be transported to the processing sites. Finding a location in this area will be difficult. The existing transfer stations, H–POWER, and the Waimanalo Gulch landfill do not have space for green waste drop–off sites.

There is public oversight at these regional facilities. A facility operator typically has the authority to establish a separate drop-off for source separated materials, but these actions may require modifications to existing permits.

Establishing separate drop-offs can produce substantial amounts of clean materials that produce highly marketable compost products.

Separate drop-off areas at existing regional facilities could increase traffic at those facilities.

Currently, the following regional facilities have commercial drop-off of green waste:

- Hawaiian Earth Products
- Kalaheo Green Waste Recycling Facility

Table 3-2
Collection Options

TYPICAL EVALUATION CRITERIA	OPTION 1 Regional Facilities Drop-Offs	OPTION 2 Satellite Drop-Off Sites For Green Waste Supervised	OPTION 3 Neighborhood Drop-Off Sites For Green Waste Unsupervised	OPTION 4 Green Waste Curbside Collections
1. Reduction Effectiveness	Fairly effective in obtaining clean loads of materials and increasing diversion rates.	Fairly effective for obtaining clean loads. Possible 20-25% commercial green waste could be collected.	Not enough data available to predict effectiveness.	Residential curbside collection programs have participation rates of 50-90%. Approximately 35-65% residential green waste may be collected.
2. Hazard Created	Creation of odors. Increased fire potential. Could increase traffic. Not likely to increase worker safety risk.	Creation of odors. Increased fire potential. Could increase traffic. Not likely to increase worker safety risk.	Would increase traffic and the risk of accidents to self-haulers. Creation of odors. Increased fire potential.	Could increase the risk of accidents to workers and add to traffic congestion.
3. Ability to Accommodate Changing Economic, Technological and Social Conditions	Probably effective under wide range of conditions.	Will probably be effective under a wide range of conditions.	Problems with unauthorized dumping, especially if tipping fees rise.	Vulnerable to budgetary priorities due to high cost.
4. Potential Change in Waste	Should cause no change in generation	Should cause no change in generation	Should cause no change in generation	If curbside program employs special plastic bags or paper, these items could rise in generation.

TYPICAL EVALUATION CRITERIA	OPTION 1 Regional Facilities Drop-Offs	OPTION 2 Satellite Drop-Off Sites For Green Waste Supervised	OPTION 3 Neighborhood Drop-Off Sites For Green Waste Unsupervised	OPTION 4 Green Waste Curbside Collections
5. Ease of Implementation	Moderate capital cost. Can be rapidly implemented.	Can be easily implemented especially if a suitable site can be found, however, longer period of education/promotion would be necessary to limit illegal dumping.	Can be easily implemented especially if a suitable site, with a history of green waste collection, can be found. Minimal site changes may be needed.	Requires planning, a substantial public relations effort and household participation. Requires two or more years from program design to full implementation.
6. Facility Need	Requires only minimal site reorientation.	Requires only minimal site reorientation. Can be easily adapted to existing drop-off sites.	Requires only minimal site reorientation. Can be easily adapted to existing drop off sites.	Requires a separate drop-off area.
7. Advantages and Disadvantages of Public vs. Private Ownership or Operation	Private or public acceptable.	Public oversight could deter illegal dumping.	Public oversight could deter illegal dumping.	Operations could be conducted by a private hauler for commercial collection of green waste.
8. Consistency with Local Plans & Ordinances	Consistent with future facilities planning for private composting facilities.	May require certain permit/regulatory compliance. Would limit, if not prevent, unsuitable materials collected.	Would not be compatible with regulations prohibiting illegal dumping. Difficult to permit for land use.	High cost of program may conflict with public desire for low cost garbage collection. Traffic would increase on local streets. In accord with policies favoring environmental diversion methods.

	TYPICAL EVALUATION CRITERIA	OPTION 1 Regional Facilities Drop-Offs	OPTION 2 Satellite Drop-Off Sites For Green Waste Supervised	OPTION 3 Neighborhood Drop-Off Sites For Green Waste Unsupervised	OPTION 4 Green Waste Curbside Collections
9.	Institutional Barriers to Implementation	Modification of existing facility will reduce delays.	Lower participation rate due to inconvenience. Effective public education program must be mounted.	Lower participation rate due to inconvenience. Effective public education program must be mounted.	Higher participation rate due to convenience factor. Effective public education program must be mounted.
10.	Cost in Short- and Medium-Term	Can be implemented at a very low cost.	Costs includes roll-off containers and transportation to a facility. Cost could include on-site chipping. Personnel for supervision.	Costs include roll-off containers and transportation to a facility. Cost could include on-site chipping. Cost could include hauling to processing center or distribution point.	Cost range from $80-120/ton.
11.	End-Use/Market Availability	Can produce substantial amounts of clean materials which produce highly marketable compost products.	Can produce substantial amounts of clean materials which produce highly marketable compost products.	May collect material with unacceptable amounts of contamination.	Can produce substantial amounts of clean materials which produce highly marketable compost products.
12.	Potential for Private Sector Participation	Private participation.	Private vendor could implement site activity, including processing.	Private vendor could implement site activity, including processing.	Private vendors can participate on commercial collection or contract for residential collection.

Recommendation: The City should review the closed landfills as potential satellite drop-off points for green waste.

3.3.2 Supervised Satellite Drop–Off for Green Waste

Drop-offs at satellite locations will probably be effective under a wide range of conditions, especially with tip fee incentive. Separate drop-off should cause no change in waste generation. Satellite drop-offs can be easily implemented especially at sites with a history of yard waste collection, e.g., waste water treatment plant, golf courses, and public parks. If any site changes are needed, they will be minimal, e.g., change in layout and perhaps some paving and fencing.

A public entity controls disposal at transfer station and landfill sites; this control should extend to any satellite drop-off sites to deal with the possibility of illegal dumping.

Satellite green waste collection sites would be established for clean loads of residential and commercial green waste. Materials collected through these drop-offs could be ground onsite with a portable tub grinder or transferred raw to regional composting facilities.

A supervised satellite site would minimize the potential litter problems and contamination of the collected green waste.

On-site grinding could produce a mulch material that could be given to people using the facilities. Materials that are not distributed to the generator could be transported to a green waste composting facility for further processing.

These drop-offs are fairly effective measures for obtaining clean loads of materials and increasing diversion rates from the residential and commercial waste stream. They are not likely to increase risk to worker safety or disrupt site operations.

Establishment of satellite drop-off areas (supervised or unsupervised) may be in conflict with local land use policies and zoning ordinances.

Satellite site drop-off collection sites may involve costs of roll-off containers and transportation to a processing facility. Supervised drop-off sites can produce substantial amounts of clean materials, which produce highly marketable compost products.

The convenience centers now provide satellite drop-off for green waste. They would act as satellite drop-off sites for the residential material. Additional satellite drop-off sites could be established for the commercial materials. Ideally, these additional sites would be closer to downtown areas in which commercial contractors and landscape companies collect the green

waste.

> **Recommendation:** With the existing network of convenience centers and private composting operations that provide drop-off services, additional satellite drop-off sites may only be needed in the Honolulu collection district.

3.3.3 Unsupervised Neighborhood Satellite Drop–Off Sites for Green Waste

Unsupervised green waste collection sites would be established for clean loads of green waste from residential generators. These satellite drop-off areas would have collection containers. The material could be stockpiled temporarily on-site without any processing, or it could be ground, and left on-site to naturally decompose. This version of a large 'backyard composting' program could work with a supportive neighborhood and master composter training programs, and with general supervision by the City. However, it may be difficult to manage such facilities. The site needs to be organized or it will be reduced to an open dump. The management needed to keep it organized would probably make these sites into supervised drop-off sites.

Not enough data exists to predict the effectiveness of unsupervised satellite drop-offs initiated alone. Separate neighborhood drop-off requires little capital costs and can be rapidly implemented if a suitable site can be found. A permit would probably be required from the State for such a facility. Satellite drop-off collection sites will involve costs of roll-off containers and transportation to a processing facility. Neighborhood satellite drop-offs for clean yard waste can easily be adapted as agricultural facilities, recreational facilities, or other larger institutions with an interest in on-site composting. If any site changes are needed, they will be minimal, e.g., change in layout and perhaps some paving and fencing.

Unsupervised satellite drop-offs would increase local traffic to the area, which could lead to increased illegal dumping. The risk of accidents to self-haulers could increase. Improperly managed sites could cause odors and be subject to fires. Unsupervised satellite drop-offs can have the problems of unauthorized dumping, especially as tipping fees increase. They could collect material with unacceptable amounts of contamination.

There should be public oversight of any unsupervised satellite drop-off sites to deal with the possibility of illegal dumping. Establishment of neighborhood drop-off areas may be in conflict with local land use policies and zoning ordinances.

There are small scale neighborhood "backyard composting" programs in the City, up canyons and around agricultural lands, that are not being monitored or inspected by the City. These types of facilities could expand under a City sponsored master composter program with inspection by City personnel.

> **Recommendation**: Given the potential problems with illegal dumping,

contamination in the green waste, and negative public perception, the City should not implement unsupervised satellite drop-off sites.

3.3.4 Curbside Collection of Green Waste

Green wastes would be collected at the curbside from households. The materials collected would be transported to a composting facility. A residential curbside green waste collection program should produce a higher rate of diversion than the other alternatives discussed here.

Separate green waste collection is in accord with policies favoring a reliable and environmentally safe diversion method. Curbside service will yield a higher participation rate than satellite drop-offs due to the convenience factor. Curbside collection can produce substantial amounts of clean green waste.

Curbside collection of green waste could increase the risk of accidents to workers with the increase in traffic. The increase in traffic on local streets is unavoidable. Curbside collection of green waste is vulnerable to budget cuts since it is an incremental cost on top of the waste collection program. The higher cost of curbside green waste may conflict with public desires to have the lowest cost refuse collection service.

Curbside collection of green wastes requires planning, a substantial public relations effort, and the willingness of householders to change their habits. Implementation may require many years from program design to full implementation. Automated collection would require investment in new trucks and carts. If the material is collected manually, existing manual equipment retired from rubbish collection could be used to reduce the initial costs. No carts would be needed for manual collection. New carts would also be needed for semi-automatic collection.

The average cost of source separated curbside collection programs for green waste is in the range of $80 to $90 per ton. These programs can accommodate changing economic, social, and technological conditions. Time is needed to develop markets for green waste compost, to publicize changes to the collection system, and to acclimatize the public to them. Technological changes involving product marketing favorable to composting would be readily accommodated.

The curbside program would be consistent with local policies, plans and ordinances. Institutional barriers consist largely of the time needed to get the collection program established and the time and effort needed to develop the markets for the compost. The City is aware of the potential dangers of weak compost markets. As more green waste collection programs come on line, a phased-in market development program will be required.

Recommendation: The City should implement curbside collection of green waste.

3.4 COST OF COLLECTION

Estimating the cost of collection for the City's green waste involves evaluation of the frequency of collection, the type of equipment to be used, cost of collection crews, equipment maintenance, distance from the centroid of waste generation in the collection district to the processing facility, and numerous other variables. These variables are included in a Collection Cost Model.

The Model focuses on the following three types of collection methods, although it can be modified to evaluate other options.

- Automated Collection Using Side-Loader Trucks
- Manual Collection Using Rear-Loader Trucks
- Claw Attachment on a Rubber Tire Loader using Rear-Loader Trucks

3.4.1 Description of Collection Methods

Automated

The City uses automated side-loader vehicles, with bodies manufactured by Heil and Wayne/Leach, to provide automated service for rubbish. The trucks range from 22 to 24 cubic yards in capacity. The carts used for municipal solid waste (MSW) are a 96-gallon Schaefer European design.

The vehicles being used for MSW collection can also be used for green waste collection. Future purchases of side-loader vehicles for MSW collection need not make special consideration for green waste collection. This allows the City to streamline purchase decisions in selecting side-loader vehicles when both MSW collection and green waste collection are underway.

There are several advantages to using automated equipment for collecting green waste. The savings in personnel and workers' compensation costs are the same as with rubbish collection. The same equipment can be used as for rubbish collection, providing flexibility in the collection system.

The disadvantages of using automated equipment involve the collection frequency. If the waste is not collected frequently enough, odors will be generated. The odors should be expected after the material has been in the container for less than a week, if grass waste is part of the material. Other green materials may be stored for longer periods. The amount of waste that can be put in the cart is limited by the volume capacity of the cart. Green material will need to be cut to length to fit.

Manual

The City now uses rear-loader vehicles to provide monthly green waste collection services. These services are provided only on routes that have automated MSW collection. The majority of the rear-loaders are International 20-cubic yard compactors. Residents place bundled green waste at the curb on the day of pickup. Under the union contract, each three-person crew is limited to collecting 24,000 pounds (12 tons) of rubbish per day. Since there is less green waste than rubbish, we have assumed a 36,000 pound per day limit, which equates to roughly 900 households at an average set-out rate of 40 pounds per household per week. Due to this limitation, the Cost Model estimates a high cost for manual collection in districts that generate large amounts of green waste. The model calculates that a second or third truck is needed to collect the entire tonnage of green waste generated in the district.

The advantages of the manual system include the ability of the householder to place larger amounts of material for collection than with the automated system. The odor will be reduced somewhat due to the open air exposure of the waste.

The disadvantages include the cost of manpower and worker's compensation issues. The current 24,000 pound per day collection limit (36,000 pounds in our assumptions) is also a disadvantage to system efficiencies.

Claw and Rear Loader

Some cities use modified rear-loader collection vehicles and small rubber tire loaders with a "Tink Claw" implement attached to provide green waste collection. This attachment operates similar to a crab's claw in the way it grabs the loose green material. Most of the small pieces are captured with the larger material.

The City would need to alter rear-loader vehicles used for green waste collection to allow for direct insertion of the green waste into the hopper by the claw. This alteration requires extending the opening at the top of the hopper an additional three feet. This minor alteration may be done locally or is available commercially as a new tailgate/hopper assembly. The alteration of the hopper for green waste collection will not preclude the vehicle from being used for curbside rubbish collection.

The small rubber tire loader, such as a CAT 914, with the Tink Claw attached is commercially available. The Tink Claw is mounted in place of the typical 2-4 cubic yard material loading bucket. The claw is hydraulically controlled by the operator to "pinch" piles of green waste. The claw is typically able to grasp up to a five cubic foot pile of green waste in one to two passes. The five-foot dimension limits the length of the material placed in the pile to ensure the green waste can be loaded into and compacted by the altered rear-loader vehicle. This method allows the residents to pile their green waste material in the street without the need to containerize the

material as in the automated method, or bundle it, as in the manual method. There is typically no limit to the number of piles the householder may place in the street, but the placement of the waste may interfere with on–street parking.

There are several advantages to the claw method. The method will most likely produce the highest participation rate by the residents because of its convenience. The material to be collected does not have to be containerized or bundled (as with the manual method).

The disadvantages include a reduction in on–street parking due to the piles of green waste. The grass adjacent to the street will be damaged by the claw during collection, if the waste material is placed on the grass. During wind storms, the waste material may blow around. In some areas, the material left after collection may get into the storm drains and cause clogging. While most of the grass cuttings and leaves are picked up with the claw, some will be missed. Either the resident will clean up these fine materials or the City will collect them with street sweepings. They may also become wind-blown litter.

3.4.2 Estimated Cost of Collection

This section summarizes the cost of collection as estimated by the Cost Model. The assumptions used are indicated in the tables.

The City is also evaluating a change in refuse collection frequency from twice-per-week to once-per-week. With the transition to an automated system and with changes to the collection frequency of waste, the City has the opportunity to implement green waste collection at a lower cost. The necessary collection equipment and collection crews should be available, which would reduce the cost of converting to curbside collection of green waste.

The discussions in this section and in the analysis in the Cost Model do not assume any savings by combining the green waste program with the institution of weekly rubbish collection. The costs provided here assume that the City will implemented curbside collection of green waste with new equipment and additional collection personnel.

Tables 3-3, 3-4 and 3-5 compare the cost of manual, automated and claw collection in several collection districts to the national averages provided by reports from Franklin Associates and Ecodata, which are discussed in the next section. The Franklin and Ecodata work compared the cost of collection of green waste and curbside recyclables in several communities.

All three tables assume bi-weekly collection with a 50 percent recovery of green waste. Each of the tables considers a different type of collection equipment (manual, automated and claw). The evaluation of cost for manual collection assumes that the union rules limit collection crews to 36,000 pounds per day. The current 24,000 limitation is expected to be increased due to the lesser

amount of green waste to be collected. There are several other important assumptions associated with the cost estimates. They are listed in Appendix A.

Table 3-3, Comparison of Collection Cost with Manual Equipment, shows the weighted average cost for the City based on the cost in the collection districts. The National Benchmarks shown suggest that the costs estimated for the City are within the range of cost observed in operating programs on the mainland (the Ecodata information) and in cost estimates based on achieving a total of 50 percent diversion from green waste and curbside recycling (the Franklin report). The tables for automated and manual collection with the claw have similar comparisons.

Each table shows a weighted average of 577 pounds per household per year of green waste recovered based on a 50% recovery rate for all collection districts combined. This value is about the same as both the Franklin (theoretical value) and Ecodata (case study) values.

Table 3-3
Comparison of Collection Cost with Manual, Bi-Weekly Collection

	Waste Collection District				National Benchmarks	
	All Districts*	Honolulu	Ewa	Koolaupoko	Franklin	Ecodata
Generation lbs/hh/year	1,117	1,292	902	1,379	1,480	1,120
Recovery Rate of Green Waste	50%	50%	50%	50%	50%	50%
Recovery lbs/hh/year	577	646	451	690	740	902
Cost/ton	$104.99	$75.40	$81.76	$76.00	$91.11	$74.00
Cost/hh/month	$2.41	$1.97	$1.42	$2.18	$2.81	$1.24
Residential Waste Recycling Rate	13.7%	14.8%	17.1%	14.2%	27.0%	17.0%

*Weighted average for all seven collection districts.

Table 3-4 Comparison of Collection Cost with Automated Equipment, uses the same basic assumptions as Table 3-3.

Table 3-4
Comparison of Collection Cost with Automated, Bi-Weekly Collection

	Waste Collection District				National Benchmarks	
	All Districts*	Honolulu	Ewa	Koolaupoko	Franklin	Ecodata
Generation lbs/hh/year	1,117	1,292	902	1,379	1,480	1,720
Recovery Rate of Green Waste	50%	50%	50%	50%	50%	50%
Recovery lbs/hh/year	577	646	646	690	740	560
Cost/ton	$118.42	$88.06	$113.46	$91.56	$91.11	$74.00
Cost/hh/month	$2.72	$2.30	$1.97	$2.63	$2.81	$1.27
Residential Waste Recycling Rate	13.7%	14.8%	17.1%	14.2%	27.0%	17.0%

*Weighted average for all seven collection districts.

Table 3-5, Comparison of Collection Cost Using the Claw, uses the same basic assumptions as Tables 3-3 and 3-4.

Table 3-5
Comparison of Collection Cost with Claw and Rear Loader, Bi-Weekly Collection

	Waste Collection District				National Benchmarks	
	All Districts* (weighted average)	Honolulu	Ewa	Koolaupoko	Franklin	Ecodata
Generation lbs/hh/year	1,154	1,292	902	1,349	1,480	1,720
Recovery Rate of Green Waste	50%	50%	50%	50%	50%	50%
Recovery lbs/hh/year	577	646	451	690	740	560
Cost/ton	$86.79	$76.11	$82.59	$76.62	$91.11	$74.00
Cost/hh/month	$1.97	$1.99	$1.44	$2.20	$2.81	$1.27
Residential Waste Recycling Rate	14.2%	14.8%	11.9%	17.9%	27%	17%

Using the assumptions shown in the tables, the weighted average cost per ton for manual collection city–wide is approximately $91.49, compared to the $91.11 and $74.00 for Franklin and Ecodata. The cost per household per year and per month fall between the Franklin and Ecodata values, indicating that the Cost Model estimates costs within the range of operating systems.

The costs of collection in the same collection district varies with the collection method because the number of households and tons to be collected vary widely. In addition, the distance to the processing location is different, which also effects the number of trucks and collection crews needed.

The detailed summary of costs for each of three recovery rates (25 percent, 50 percent, and 75 percent), each of the collection frequency (weekly, bi–monthly, and monthly), each of the collection districts, and each of the three methods of collection are in Appendix A. Comparing the costs for one method over different districts, recovery rates, and frequencies, one observes that the cost does not always change. The lack of sensitivity to the variables results because the amount of material being collected does not require additional trucks with increasing recovery rates or decreasing collection frequency.

This cost evaluation included a limit of 36,000 pounds per day on collection by manual crews. The number of households overrides the cost impact of the 36,000 pound limit on weekly collections in all districts. The weight limit controls for most districts for monthly collection. For bi-monthly collection and 50 percent recovery, the controlling influence depends on the collection district; the cost in districts with more waste is controlled by the 36,000 pound limit.

Appendix A also includes a list of assumptions used in the cost calculations. The prior three tables provided a summary of the cost of collection for one case, 50 percent recovery with bi–weekly collection frequency. The cost of each of the three methods of collection was identified. **Table 3-6** summarizes the city–wide weighted average cost of collection for all three methods, recovery rates, and collection frequencies. This table shows that the least expensive (on a dollar per household basis) collection method is the claw on a monthly basis with 25 percent recovery. This monthly frequency may be too long for storage of the material without odor impacts and the claw collection method may have unsatisfactory impacts, as discussed earlier. Bi–weekly collection is probably the least frequent acceptable method. Although the automated method is somewhat more costly than the manual method, it is the preferred collection method for rubbish. As a result, we recommend the automated method on a bi–weekly frequency.

Table 3-6
Weighted Average Collection Cost

Frequency and Recovery Rate	Manual		Automated		Claw	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly Collection						
25%	$113.63	$1.25	$168.95	$1.87	$106.90	$1.18
50%	$104.99	$2.41	$118.42	$2.72	$81.91	$2.02
75%	$78.50	$2.66	$82.40	$2.79	$63.40	$2.15
Bi–weekly Collection						
25%	$147.70	$1.66	$187.19	$2.11	$133.34	$1.51
50%	$90.13	$2.04	$116.72	$2.63	$87.00	$1.97
75%	$78.50	$2.66	$94.63	$3.20	$71.33	$2.42
Weekly Collection						
25%	$176.68	$2.10	$230.70	$2.77	$147.55	$1.78
50%	$121.23	$2.73	$142.78	$3.23	$102.35	$2.32
75%	$97.07	$3.28	$108.72	$3.67	$84.68	$2.87

3.5 COST OF CURBSIDE COLLECTION IN OTHER JURISDICTIONS

Tables 3-3, 3-4, and 3-5 compared the estimated cost of collection in Honolulu to studies done by Franklin & Associates and Ecodata. This section discusses the details of the Franklin report, titled "Solid Waste Management at the Cross Roads," December 1997, and the Ecodata study, titled "Recycling and Yard Debris Collection: State of the Industry," December 1997.

The Franklin study differs from the Ecodata study in one important way. It evaluates the cost of achieving 50 percent diversion using a green waste collection and a program collecting recyclables at the curb. The Ecodata study compared the cost of several operational curbside green waste collection and curbside recyclable collection programs. The programs varied in effectiveness, cost,

and years they had been operating. The results from the two studies are not necessarily comparable.

There has been increasing interest in diverting green waste. For example, green waste processing facilities have increased in number from less than 1,000 in 1988 to over 3,400 in 1997, according to a nationwide survey by Biocycle. With the development of the green waste processing industry, there have been a number of studies and reports published by federal and state government agencies and by consultant groups over the last year.

Table 3-7 taken from the Franklin Report is reproduced below. It summarizes the relative costs of green waste collection and composting. The costs of municipal solid waste management alternatives were estimated using common assumptions to enable comparison of the costs of different programs. The cost analysis assumed recovery rates for both curbside recycling and green waste programs to achieve an aggregate 50 percent diversion rate.

Franklin concluded that green waste recycling is the most cost-effective recovery alternative evaluated. Franklin based this conclusion on the following:

1. Green waste can be diverted at an average cost of $101.11 per ton at 27 percent diversion rate compared to an average of $181.47 per ton for curbside recycling, which has a 23 percent diversion rate.

2. Collection costs are $63.11 per ton, $23.33 per household per year, or $1.94 per household per month.

3. Relatively low operating costs to compost the yards trimmings ($38.00 per ton, $14.05 per household per year, or $1.17 per household per month).

4. Revenue from the sale of the finished compost.

Based on an average household generating 2,700 pounds of waste per year and the assumed recovery rates, a curbside recycling program would collect 610 pounds and a green waste program would collect 740 pounds.

Table 3-7
Metropolitan Area Household Solid Waste Management Costs, 1996
With Expanded Case Curbside Recycling And Yard Trimmings Composting [1, 2]

	Household Quantity	Household Cost		
	(Tons/Year)	($/Ton)	($/Year)	($/Month)
Refuse collection & transport	0.665	97.25	64.63	5.39
Refuse landfilling [3]	0.665	28.90	19.21	1.60
Refuse landfilled subtotal	**0.665**	**126.15**	**83.83**	**6.99**
Drop-off/buy-back recycling	0.012	0.00	0.00	0.00
Curbside recyclables collection	0.305	114.47	34.91	2.91
Curbside recyclables processing [4]	0.305	67.00	20.43	1.70
Curbside recyclables recovery subtotal	**0.305**	**181.47**	**55.34**	**4.61**
Curbside recyclables revenues [5]	0.305	45.19	13.78	1.15
Net curbside recycling costs	**0.305**	**136.28**	**41.56**	**3.46**
Yard trimmings collection	0.370	63.11	23.33	1.94
Yard trimmings composting [6]	0.370	38.00	14.05	1.17
Yard trimmings recovery subtotal	**0.370**	**111.11**	**37.38**	**3.12**
Compost revenues [7]	0.370	10.00	3.70	0.31
Net yard trimmings composting costs	**0.370**	**91.11**	**33.69**	**2.81**
Total solid waste management costs	**1.351**	**117.73**	**159.08**	**13.26**

For an avg. single-family metropolitan household generating 52.0 pounds/week of MSW (not incl. bulky durable goods).

Assumes collection and disposal of approximately 25.6 pounds/household/week; recovery of 0.46 pounds/household/week through recyclables drop-off/buy-back programs and 11.73 pounds/household/week through curbside recycling of ONP, mixed paper, steel and aluminum cans, PET and HDPE containers, and glass bottles and jars. Also assumes separate collection of yard trimmings (14.22 pounds/household/week) for composting.

Landfill size assumed for population base of 250,000; estimated at 683 tons/day (306 days per year of operation) from 825 tons/day before curbside recycling and yard trimmings composting.

Assumes MRF operating at 84 tons/day before curbside recycling and yard trimmings composting.

Reflects calculated average market prices during the 1990s for the designated recyclables.

Assumes composting operation at 102 tons/day, 260 days/year.

Assumes 50 percent of incoming yard trimmings as finished compost at $20/ton.

NOTE: Numbers may not add to totals due to rounding.

SOURCE: Franklin Associates, Ltd.

Ecodata recently surveyed the solid waste management practices of over 40 communities located throughout the United States. **Table 3-8** from the Ecodata study provides quantities, diversion, and cost of curbside and green waste recycling programs. **Table 3-9** reviews curbside recycling practices between 1994 and 1997.

Table 3-8
Quantities, Diversion and Cost of Curbside Recycling Programs

Item	Percent Curbside Diversion [1]			All
	<10	10-20	>20	
Tons per household per year [2]				
Recyclables	0.12	0.23	0.34	0.23
Refuse	1.36	1.24	0.82	1.13
Yard debris (those with program)	0.34	0.23	0.29	0.28
Yard debris averaged across all communities	0.18	0.20	0.19	0.19
Total discards	1.66	1.67	1.35	1.55
Diversion (Percent)				
Curbside	7.32%	13.74%	25.41%	14.80%
Yard debris	20.48%	13.77%	21.48%	18.10%
Cost ($per ton collected)				
Curbside recycling	$124.68	$142.44	$104.31	$127.00
Refuse collection	$43.71	$64.17	$98.11	$69.00
Cost per household				
Curbside recycling	$15.26	$29.90	$34.40	$28.76
Refuse collection	$58.52	$80.01	$73.23	$68.23

1. Single-family curbside recycling diversion, not including yard debris.
2. Differences between groups are statistically significant at the 90 percent level of confidence.
Source: Ecodata, Inc. 1998

Table 3-9
Curbside Recycling Practice Over Time [1]

Item	1994	1997
Tons collected per household per year		
Curbside recycling	0.15	0.23
Refuse	1.34	1.13
Yard Debris	0.06	0.19
Total	1.55	1.55
Diversion rates (Percent)		
Curbside recycling – average	9.7	14.8
Minimum – maximum	0.5 to 25.40	0.5 to 37.3
Yard debris – average	3.9	12.3
Total Recycling (yard debris and curbside)	13.6	27.1
Cost/household (Constant – 1997 dollars)		
Curbside recycling	$27.72	$28.76
Refuse collection (no disposal)	$77.89	$68.23
Yard debris collection	$4.77	$15.21
Total	$110.38	$127.42
Percent of Communities		
with Curbside recycling	76.7	100
with Yard debris programs	26.7	82
Cost per ton in communities with specified programs (Constant – 1997 dollars)		
Curbside recycling (no disposal)	$184.80	$127.00
Refuse collection (no disposal)	$58.12	$69.00
Yard debris collection	$79.46	$74.00

1. Tons and costs are allocated across all communities, with and without specific recycling programs.1994 figures are for whole sample, of which 77 percent had curbside recycling programs and 27 percent had yard debris programs. 1997 figures are for whole sample, of which 100 percent had curbside recycling programs and 82 percent had yard debris programs. For those communities with programs, tons collected and diversion rates are higher. See Table 3-7 above for the data for communities with yard debris and recycling programs.
Source: Ecodata, Inc., 1998.

The Ecodata information reveals a few additional insights in relation to the Franklin Report. However, Ecodata did not disaggregate the data for communities with both curbside collection of recyclables and green wastes, but combined the information for all of the 40 communities.

Ecodata did reveal that green waste collection programs yield diversion rates of over 20 percent. In communities that offered green waste programs, an average of 560 pounds per year was diverted, a figure that exceeds the 460 pounds per year for curbside recycling collection programs. The Ecodata information was modified in a manner to highlight the additional diversion achieved by instituting green waste collection programs.

Table 3-10 compares the summary of the estimates reported by Franklin and the data reported by Ecodata. It must be noted that the Franklin data reflect their estimates of cost and recovery needed to achieve 50 percent diversion and Ecodata reports the average results for the 40 communities they surveyed. While the data are not directly comparable, they do present a range of costs to which the City can compare its cost estimates.

Table 3–10
Comparison of Franklin Cost Estimates with Ecodata Survey Results

	Franklin Report Relative costs to get to 50 percent (1996 Dollars)		**Ecodata Survey of 40 Communities (1997 Dollars)**	
Household Quantities	Pounds per household per year	Percent	Pounds per household per year	Percent
Total Solid Waste Generated	2,702	100	3,100	100
Disposal	1,330	49	2,260	69
Curbside Recycling	610	23	460	14
Green Waste Recycling	740	27	560	17
Curbside Recycling Cost (per ton)	$136.28		$127.00	
Curbside Recycling Cost (per household per year)	$41.56		$28.76	
Green Waste Cost (per ton)	$91.11		$74.00	
Green Waste Cost (per household per year)	$33.69		$15.21	

3.6 PROCESSING OPTIONS

There are currently two major processing options on Oahu. Hawaiian Earth Products is located in Campbell Industrial Park on the leeward side of the island. Kalaheo Green Waste Recycling Facility is located in Kalaheo on the windward side of the island. Smaller operations include Hawaii Reserves Inc. in Laie, at the north end of the island, and Unisyn BioWaste Conversion in Waimanalo on the windward side (Unisyn is no longer in business). The City also accepts green waste at its Kapaa Transfer Station on the windward side of the island, which is ground into mulch.

These processing facilities are not located in the area of greatest green waste generation. There is potential for a third major green waste processing facility near the center of the urban area closer to the point of generation.

This section summarizes the operations of HEP and Kalaheo and discusses the conditions under which a third processing transfer site would be needed.

3.6.1 Hawaiian Earth Products

HEP is located on a 10-acre site in Campbell Industrial Park. It receives approximately 2,000 tons per month of commercial green waste, green waste from City residential collection and convenience centers (located in Ewa, Waianae, Wahiawa, Waipahu, and Laie), and composted steer manure. The site processes approximately 75 tons per day in a 6-day operating week. The facility does not receive any agricultural waste and receives minor amounts of grass clippings. Green waste must be separated from all contaminants such as cans, glass, cardboard, chemicals, soil, rock, concrete, pipes, metals, and household trash. The tipping fee is $40 per ton.

The facility is well equipped with the state-of-the-art machinery to process the material. The grinding equipment consists of a Diamond Z for processing the green material, an Eliminator III trommel and a Recycling System Inc. trommel to screen and size the composted material, and two-wheel loaders to move material.

The site can be expanded from the current size of 10 acres to 17 acres. The development of the site needs to consider a sustained and affordable source of water to implement a dust control program and a fire protection plan. The site could (with the additional 7 acres and its existing processing equipment) handle 250 tons per day of green waste, wood products, manures, and other types of feedstock and materials.

HEP uses locally generated materials to produce organic soil amendments. HEP processes a series of organic soil amendments and custom blends for sale as listed below.

- **Soil conditioner**: composted and screened green waste
- **Compost:** composted and screened green waste and steer manure
- **Cover Mulch:** Large size mulch for ground cover/weed control
- **Nursery #1:** 2/3 screened topsoil and 1/3 screened soil conditioner
- **Nursery #2:** 2/3 screened topsoil and 1/3 compost
- **Nursery #3:** ½ screened topsoil and ½ compost
- **Menehune Magic:** Bagged compost product
- **Other blends**

Based upon an input of 75 tons per day of green waste, approximately 35 to 40 tons of organic products are produced.

3.6.2 Kalaheo Greenwaste Recycling Facility

Kalaheo (Kalaheo Greenwaste Recycling Facility) is located on a 10-acre operational area on top of the closed Kalaheo Landfill. The facility has been operating since 1996. Currently, Kalaheo receives approximately 40 tons per day of commercial green wastes. The facility does not receive any agricultural wastes or manures.

The commercial green waste loads are clean with an extremely low percentage of contamination. Kalaheo charges a tipping fee of $32 per ton. The tipping fee at the nearby Kapaa Transfer Station is $98.75 per ton.

The facility provides a load-checking program to minimize the amount of contamination in incoming material.

The facility is equipped with adequate machinery to process the incoming material. The grinding equipment consists of a Morbark for processing and an RSI trommel for screening. One loader is on site to manage the compost piles.

The site can not be physically expanded, but throughput could be increased with additional resources. The site Operations Manual calls for additional equipment and personnel to enable the facility to receive up to 240 tons per day of green wastes. The site development plan is specific in terms of fire prevention, storm drainage, road maintenance, and site security because of its

placement on top of a closed landfill.

Kalaheo processes three types of products for sale as listed below:

No. 1 Top Dressing	Mulch product
No. 2 Compost	Compost fines
Overs	Wood chips

Kalaheo produces these as bulk products and is not bagging compost for retail sales at this time.

3.6.3 Need for Additional Processing/Transfer Site

The need for an additional processing facility is based on whether there is a shortage of processing capacity for the amount of material expected and on the cost for transporting the material from the point of generation to the processing site. This section reviews these two considerations.

The current combined throughput of the two major green waste processing facilities is estimated to be 115 tons per day, and their combined maximum capacity is estimated to be 490 tons per day. Their feedstock is from existing commercial and residential collection programs.

Expanding the residential green waste collection program will add 110 tons per day assuming a 50 percent recovery rate. The amount of commercial green wastes that remains in the total waste stream to be recovered is 151 tons per day. Given the difference in the fee for disposal and the fee for processing, we would expect all of it to be recovered. If so, the total demand on the processing facilities would be 376 tons per day, less than the 490 tons per day capacity of the two facilities. As such, there is no need for another facility to process the additional green waste that is expected to be collected because existing capacity is adequate.

The need for a transfer site can also depend on the location of processing sites and the area where the waste is generated.

The two existing processing facilities are located at opposite sides of the island. Table 2-1, Green Waste Amounts, shows that the Honolulu Collection District generates the majority of the residential green waste. Waste from the other two large generation districts, Ewa and Koolaupoko, would be close to HEP and Kaleheo, respectively. In addition, material from the east half of the Honolulu District would be closest to Kaleheo. The travel time from West Honolulu would be lengthy, although either of the two existing sites could handle the tonnage.

There is an opportunity for a third major facility that is centrally located. To reduce the travel time to West Honolulu, the processing/transfer facility could be located in the Sand Island or Middle Street areas. A facility located in these areas probably would not have sufficient land for windrow

processing. Since the two major processing facilities have adequate capacity for the additional green waste, composting capacity is not needed. Rather a size reduction and transfer facility would be appropriate.

There are several issues associated with getting approval for any waste related facility. The issues include noise, odors, dust and traffic. In addition, locating property with the appropriate zoning may be difficult. In Honolulu, the cost of leasing or buying the property is high, especially in the central area.

For such a facility to be viable, the cost of processing and transportation of the more dense load would need to be less costly than direct haul and the tip fee at the processing site. The most direct way to determine the viability is to issue a request for proposals to provide the site, equipment, labor, and waste processing service.

The siting of a processing facility may be difficult in absence of clear local or state guidance, and because of the potentially conflicting land use policies and sensitive neighbors. Delays may be reduced if a processing facility is sited at an existing solid waste facility or at other public facilities, such as sewage treatment plants, where there is existing infrastructure. Neighboring residents may oppose the siting of a processing facility in their neighborhood due to concerns that the facility is just a different type of garbage dump, as opposed to the facility managing select loads of organic materials.

Siting a processing facility may require a form of flow control, which can be difficult to negotiate among competing private interests. Without assurance of flow control, it may be very difficult to attract capital investment to a facility. Mechanisms for insuring flow control include ordinances, licenses, contracts, and tipping fee incentives. As long as it exists, the current tipping fee incentive in Honolulu would provide the needed flow control.

3.6.4 Green Waste Processing Alternatives

This section discusses the general considerations for a green waste processing facility. It is a an overview of the siting and operating requirements of the different processing technologies. The processing facility would accept mixed yard wastes, including leaves, grass, brush, and prunings, for composting into marketable products. The facility could also accept wood wastes, of which some would be composted and some would be processed into mulch, fuel, and other useful products. Without Waialua Sugar, the market for fuel will have to be developed.

Windrow Green Waste Composting

Windrow composting would take place in an open field in long piles (windrows) approximately 6 to 8 feet high and 10 to 12 feet wide (length depending on the configuration of the site). The windrows would be turned periodically for aeration and would be screened after a 45 to 90 day

curing period. It involves use of machinery and will produce leachate, diesel exhaust, odors, noise, and dust. It is not adaptable to a rapidly urbanizing environment due to large land requirements (usually ten acres or more) and to nuisance odors. A windrow facility, which originally had no neighbors, can become a nuisance when an area becomes developed. Systems that process only yard wastes are less adaptable to changing waste stream composition and will need to be carefully managed.

Composting facilities will need to be consistent with local zoning. Windrow facilities are likely to be delayed during the planning process due to concerns about nuisance odors. Windrow systems require extensive equipment, such as grinders, large screens, compost turners, and wheel loaders.

Reported yard waste/windrow operational costs are in the range of $30 to $40/ton. This cost range assumes source separated collection of materials to minimize contamination. A windrow composting system with clean feedstock can produce a quality product.

In-Vessel Green Waste and Source Separated Organic Materials

This alternative would place the green wastes as a bulking agent with other organic material within an enclosed vessel. In-vessel system would allow the composting of other waste streams to provide an effective solution to the management of those waste streams. Other source-separated organic material that could be mixed with green wastes would include wood wastes, pre-consumer food wastes, agricultural wastes, cannery wastes, and sewage sludge (biosolids).

In-vessel composting would involve heavy machinery. Due to the enclosure of the building, odors, noise, and air pollution exposures could be more hazardous to workers. The more complex the mix of materials, the higher the potential for problems in these areas. Composting green waste alone would be fairly routine and would substantially reduce the impacts associated with open-air windrow composting. Composting a mix of organics would involve transfer and pre-processing that would need to be carefully managed.

In-vessel systems with odor control can be sited in relatively small areas and should not pose a nuisance in an industrial zone.

The cost for facilities with two or more source separated materials may range from $50-60/ton depending upon the system being implemented. This cost is based on the cost of an in-vessel system processing sludge and MSW.

Mixed Municipal Solid Waste Composting

This type of facility would accept MSW for composting into a marketable product. The facility would use manual and automated processing to remove non-compostable materials (metals, glass, and bulky materials) from incoming wastes, leaving the organic fraction (food wastes, plant material, paper, and other miscellaneous organics) for composting. The organic fraction would be composted in an enclosed vessel into a stable end product that can be used as a soil conditioner, organic fertilizer, or cover material.

Mixed waste processing has the largest diversion potential since it would compost materials that cannot otherwise be recycled, such as contaminated paper.

Facility needs are most extensive for in-vessel composting of MSW. It requires an extensive system for removal of contaminants, such as batteries.

Mixed waste processing costs in the range of $50-70/ton and is the most capital intensive processing method. However, it can be implemented without source separated collection. Sales of recyclables captured at the front end of the facility can defray a portion of the total facility costs.

These systems can readily adapt to changes in waste stream composition and do not require specialized collection methods. There would be no need to source-separate organic materials, or have specific collection routes for green wastes. The economic viability will be hampered by the uncertainty of markets for mixed waste compost.

There is no known market for mixed waste compost in Honolulu. Pilot tests on the mainland have indicated that an acceptable (but not top grade) soil amendment could be made from mixed waste compost. It might have its largest application in orchards and in land reclamation, e.g., landfill closure. Pilot tests in Santa Barbara County, California, have also suggested that non-recyclable paper composted with sludge can produce a useful mulch product for gardening and slope stabilization.

Summary of Alternatives

Table 3-11, Composting Programs Evaluation Matrix— Processing Alternatives, summarizes the features of the processing methods.

Table 3-11
Composting Programs Evaluation Matrix

INITIAL EVALUATION CRITERIA	OPTION 1 Yard Waste Composting (windrow)	OPTION 2 Yard Waste Composting (in-vessel)	OPTION 3 Source Separated Materials (in-vessel)	OPTION 4 Mixed Municipal Solid Waste Composting (in-vessel)
1. Reduction Effectiveness	Typically results in 50% reduction in weight and 60-70% reduction in volume. Rejects to be landfilled or reprocessed may range from 1-10%.	Typically results in 50% reduction in weight and 60-70% reduction in volume. Rejects to be landfilled or reprocessed may range from 1-10%.	Typically results in 50% reduction in weight and 60-70% reduction in volume. Rejects to be landfilled or reprocessed may range from 1-10%.	Has the largest reduction potential since it composts multiple materials. Typically results in 50% reduction in weight and 60-70% reduction in volume. Rejects to be landfilled or reprocessed may range from 1-40%.
2. Hazard Created	Potential hazards include health and safety hazards to facility employees, diesel exhaust, noxious odors, noise, dust, microbes and leachate generated by the facility and use of machinery.	Decrease in danger posed by air pollutants, noxious odors, noise, dust, microbes and leachate due to enclosure of the facility. Use of heavy machinery also poses a problem.	Poses little environmental threat. Low in heavy metals and pesticides.	Poses little environmental threat.
3. Ability to Accommodate Changing Economic, Technological and Social Conditions	Not adaptable to urban environment due to land use requirements and uncontrolled odors. Less adaptable to changing waste stream and requires specialized collection system .	In –vessel systems with odor control can be sited in relatively compact areas of 5 acres. Does not pose a nuisance in an industrial zone. Less adaptable to changing waste stream. Requires specialized collection system.	In –vessel systems with odor control can be sited in relatively compact areas of 5 acres. Does not pose a nuisance in an industrial zone. Can readily adapt to changes in waste stream composition. Requires a specialized collection system.	In –vessel systems with odor control can be sited in relatively compact areas of 5 acres. Does not pose a nuisance in an industrial zone. Can readily adapt to changes in waste stream composition. No specialized collection method required.

INITIAL EVALUATION CRITERIA	OPTION 1 Yard Waste Composting (windrow)	OPTION 2 Yard Waste Composting (in-vessel)	OPTION 3 Source Separated Materials (in-vessel)	OPTION 4 Mixed Municipal Solid Waste Composting (in-vessel)
4. Consequences on Characterized Waste	Compost may be bagged or sold in bulk.	Compost may be bagged or sold in bulk.	High value compost may be bagged or sold in bulk.	Mixed waste compost may not be bagged due to low value
5. Ease of Implementation	Likely to be delayed by nuisance odors and large land requirements.	High capital cost. Technically complex and could require several years for planning and implementation.	High capital cost. Technically complex and requires several years for planning and implementation.	High capital cost. Technically complex and requires several years for planning and implementation. Hampered by uncertainty of markets for mixed waste compost.
6. Facility Need	Requires a large site and extensive equipment such as grinders, large screens, compost turners and front-end loaders.	Requires the construction of a building with complex equipment.	Requires the construction of a building with complex equipment.	Requires the construction of a building with complex equipment. Facility needs a more extensive system for removal of recyclables and contaminants.
7. Advantages and Disadvantages of Public vs. Private Ownership or Operation	Public or private activity at required site appears equally of value.	Public or private activity at required site appears equally of value.	Public or private activity at required site appears equally of value.	Public or private activity at required site appears equally of value
8. Institutional Barriers to Implementation	Difficult in absence of clear state guidance, and conflicting requirements of various regulatory agencies.	Difficult in absence of clear state guidance, and conflicting requirements of various regulatory agencies.	Difficult in absence of clear state guidance, and conflicting requirements of various regulatory agencies.	Difficult in absence of clear state guidance, and conflicting requirements of various regulatory agencies.

INITIAL EVALUATION CRITERIA	OPTION 1 Yard Waste Composting (windrow)	OPTION 2 Yard Waste Composting (in-vessel)	OPTION 3 Source Separated Materials (in-vessel)	OPTION 4 Mixed Municipal Solid Waste Composting (in-vessel)
9. Cost in Short and Medium-Term	Range from $30/cu yd or $40/ton.	$40-60/ton depending on system implemented.	Demands specialized collections of materials which raise total program cost. Less financially attractive.	Technology required demands high capital.
10. End-Use/Market Availability	Markets can be developed for composts made of clean yard waste materials.	Markets can be developed for composts made of clean yard waste materials.	Markets can be developed for composts made of source separated materials.	No known market for mixed waste compost in Honolulu.
11. Potential for Private Sector Participation	Opportunities for private participation.	Opportunities for private vendors.	Opportunities for private vendors.	Opportunities for private vendors.

3.7 MARKETING

The City has a great opportunity to recycle most of the island's green trimmings and use the resulting compost to create healthier soils, cleaner waterways from less runoff, and more attractive, durable landscapes. Keeping green trimmings out of H–POWER and landfills will also improve the efficiency and longevity of those systems. These improvements will benefit resident and visitor alike. The City can take advantage of this opportunity by encouraging the collection and recycling of substantial amounts of green trimmings and then by using the finished compost on the considerable land area it manages. This collection, processing and use continuum is physically sustainable over the long run–there will always be green trimmings and most soils can easily absorb a new application of compost every year.

However, as stated previously, there will be additional collection costs associated with a clean-green program and the cost of applying the finished compost over acres of land needs to be borne by the taxpayers of the City. In addition, the collection and processing of green materials must not outpace the rate at which the resulting compost can be sold and distributed, even at zero revenue.

This section estimates the potential production of compost if all green material generated was composted. A summary of the bagged compost in the local market is provided. Finally, the potential and limitations for sales of commercially produced compost to commercial markets will be explored.

3.7.1 How Much Public Land Could Use Compost

What if 100 percent of all the green materials expected to be collected by the City in the new program were composted? Is there enough land area available to take all the resulting compost, every single year, if the compost were given for free, delivered for free, and spread and/or incorporated for free? This is a worst case scenario from a cost-recovery or revenue generation basis, but it does illustrate the issue of capacity to absorb all the compost produced.

If 266,000 tons[1] (532,000,000 lbs) of green materials are collected in 1999 and that material was transformed into 133,000 tons (266,000,000 lbs, at a 50 percent raw materials to finished compost conversion rate) or about 332,500 cubic yards (at 800 lbs/cu yard or 2.5 cubic yards to the finished ton) of compost and that material was spread 0.25 inches deep (rather conservative

[1]Of course, the amount of materials needed to be collected and processed could be reduced by increasing the number of drop-off sites for ground tree trimmings, such as the one in Manoa Valley; encouraging people to plant fewer plants; encouraging people to adopt xeriscaping; encouraging people to compost at home; encouraging agricultural and other businesses to compost on-site. Basically, encourage source reduction by whatever means appropriate.

depth[2]); how many acres of land would be needed? It takes about 34 cubic yards of compost to cover one acre at 0.25 inches, so 9,779 acres (332,500 cubic yards/34 cubic yards per acre) would be needed. According to the most recent data on "Land Use and Structural Characteristics of Oahu," there appears to be sufficient land on Oahu onto which to place all the compost that can be produced (Table 3-12). There may be some changes to the acreage in Table 3-12. Since 1994 all of the sugar plantations have closed and the acreage in agriculture may have changed.

Table 3-12
Land Use in Acres on Oahu 1994

Land Use 1994 Oahu Total	
Residential	31,098
Industrial	9,058
Commercial	4,205
Hotel	319
Agriculture	70,066
Usable vacant	38,587
Other	212,812
All existing uses	375,146

Source: Adapted from The State of Hawaii Databook 1997, Department of Business, Economic Development and Tourism, 1997, Table 6.02.

For this analysis, however, it is important to look just at the acreage under the maintenance of the City, because the City could ultimately mandate the use of compost on their lands, whereas they have no control, but could be persuasive, over the private sector, the State, and the Federal government.

[2]Compost can be valuable with a "dusting" of as little as 0.125 inches as a top-dressing on turf, to a depth of 2 inches (incorporated) for field crops, to 3 inches around trees when used as a mulch. The 0.25 inch figure chosen here was given as a conservative use. If all customers used 1 inch of compost for all their applications (134 cubic yards/acre), the amount of acres needed to use up all the compost produced would be reduced by four, or the necessary amount of acres to absorb all the compost produced would be reduced to 2,445 acres.

3.7.2 The Potential for Compost Use by the City and Its Estimated Costs

When it comes to land that is managed and green, the City maintains parks, botanical gardens, community gardens, roadsides, golf courses, and other types of lands. In 1996 the City had 6,195 acres of land in parks, 650 acres in botanical gardens, and relatively few acres in community gardens (DBEDT, 1997; City and County of Honolulu, 1997). Reports by City departments and agencies for fiscal year 1996-1997 note that some additional 820 acres of park land may come on line in the near future. The sum of these acres is 7,665, only 2,100 acres short of what is needed to absorb all the compost, at 1/4" deep, that could be produced if all of the green waste produced on the island were composted.

The park acreage that is green will typically require that the grass be trimmed and trees pruned. What is typically overlooked in good park maintenance, however, is the chance to improve the health and drainage of park soils and thus the durability of the landscapes. Drastic improvements can be made to turf areas by core aeration of the soil followed by a semi-annual or annual top-dressing of 0.125-0.25 inches of compost (annual total). The Composting Council of Maryland, the composting industry's main trade association, lists on their "Compost for Sale: A Roadmap of the Basics of Commercial-Scale Compost Production and Sales" wall poster the benefits to compost use (Tyler and Hollyer, 1995) **(Table 3-13.).**

Table 3-13
The Composting Council's List of Benefits of Using Compost

Breaks up clay soils	Contains high organic content	Dark color absorbs heat
Decreases thatch	Eases cultivation	Helps form soil aggregates
Helps prevent crusting	Helps suppress plant diseases	High Cation Exchange Capacity (CEC) ties up heavy metals
Improves drought tolerance	Improves soil structure	Increases microbial population
Increases drainage in dense soils	Increases CEC	Increases earthworm population
Increases exchange capacity of many soil types	Increases micro nutrients	Increases nutrient availability
Increases root structure	Increases soil aeration	Kills weed seeds during processing
Lightweight and easy to move	Makes weed pulling easier	May increase safety on athletic fields

Table 3-13
The Composting Council's List of Benefits of Using Compost

Promotes growth of mycorrhizae (the white fungus in a compost pile)	Provides slow release of macro nutrients	Reduces erosion
Reduces leaching	Reduces soil compaction	Replaces cover crops
Suppresses weeds when used as a mulch	Uniform texture and consistency	Versatile in wet weather

The City maintains nearly 1,350 miles of road on Oahu (City and County of Honolulu, 1997), much of which has sidewalk and an 18–inch green strip. It is unknown how many acres of land abut these roads but it is not insignificant. Judging from casual observation, many cubic yards of compost could be spread on roadsides and there would be benefits to the soil, plants and surrounding waterways.

While there is a total of 35 golf courses on Oahu, thirty 18-hole and five 9-hole, the City maintains six golf courses, five 18-hole and one 9-hole (DBEDT, 1997). The average 18-hole golf course in the state is about 157 acres of maintained land (Cox, Hollyer, Schug, 1991). Five 18-hole golf courses at 157 acres and one 9-hole course at approximately 90 acres each would mean that 875 acres of land could be available to be enhanced by the use of compost. (All Oahu courses combined would yield 5,253 acres.) A yearly top-dressing of 0.25 inches per acre over 875 acres could absorb an annual stream of 29,750 cubic yards of final, finished compost (875 acres x 34 cubic yards/acre). (Using the same numbers all Oahu golf courses could absorb 187,680 cubic yards of compost.)

The sum of the acreage in current and proposed City parks and botanical gardens and golf courses is about 8,540 acres. This contrasts well with a potential upper-end production of compost that would require an annual amount of 9,779 acres, at a conservative application rate and a very high end collection/processing rate, to absorb all the compost produced. Of course, compost use would need to be mandated by the City and the workers trained to use this soil amendment properly for the system to work smoothly.

It is important to noted that the analysis so far has excluded any discussion about the cost to the City of the compost and the cost to apply it.

3.7.3 How Much Would It Cost to Buy

An important underlying assumption of this study is that *all* green trimmings collected by haulers on the island will go largely to the two significant green material processors and not be processed in City operated facilities. If that is the case, and the City wished to use the compost that is being produced, then it must buy the compost or compensate the facility operator in some way. If the City chose not to use the compost produced, it is probably impossible for the private sector to sell this much compost to the private sector at current or even greatly reduced prices.

Assuming the City did want to buy compost to cover 8,540 acres of land to a depth of 0.25 inches every year, what would it cost and how could the City arrange to purchase it? At current market prices of around $30 cubic yard, it would cost the City $8,710,800 (8,540 x 34 cubic yards/acre x $30/cubic yard). How realistic is this type of expenditure?

In 1987, Cox, Hollyer and Schug estimated the amount of money that each county and the state and federal governments spent on the design and installation of new landscapes and the maintenance of existing ones (1991). All governments in Hawaii said they spent a total of $4.7 million on the design and installation of landscapes, and $18.3 million was spent on landscape maintenance, for a total of $23 million. In the same report, it was noted that the City reported spending $4.5 million total on these activities. Clearly, $8.7 million in compost could not be purchased using a total annual budget of $4.5 million. But how could it be done?

- A volume deal on price could be struck.
- A property tax offset could recover the operational costs of the compost producers.
- A tipping fee tax could be added (a fee of $32/ton, on top of the current tipping fee, would absorb the $8.7 million dollar cost).
- Less compost could be purchased.
- A thinner layer of compost could be applied.
- The City could produce their own compost, if they could do it cheaper than the private sector.

These or a combination of ideas could make the system work, at least in part. Yet there is one more cost, that of applying compost, often after core aeration. If it costs conservatively $10/acre to core aerate and apply 34 cubic yards of compost per acre, the additional cost would be $2,903,600. The total bill for compost purchase and application would be around $11,614,400 per year.

While this still seems like a lot of money, what is the value of keeping 266,000 tons of green materials out of H-POWER and landfills, every year for many years to come? It is difficult to estimate the opportunity cost of energy that would not be used to burn wet green materials or the space that would be saved by not burying ash or raw green materials. In addition, what is the value of cleaner (and thus more productive) waterways, more beautiful roadsides, and more durable landscapes?

3.7.4 Expanding Commercial Markets for Locally Produced Compost

The situation above illustrated just one outlet for the compost that could be produced, that of the City using most, if not all, that is available. This scenario is unrealistic because there is already a fairly substantial commercial compost industry on Oahu. Compost is imported from Maui and the mainland, and the demand for it appears to be growing. So the question becomes what could be the sustainable mix of City and commercial purchases of compost?

3.7.4.1 The Current Commercial Market for Compost on Oahu

The current or future commercial market for a finished compost on Oahu cannot be estimated with any statistical certainty. This is because:

- Sales figures from large Oahu-based composters or compost packagers are confidential. Sales of Eko compost (made on Maui) on Oahu are confidential.
- Detailed import figures for mainland produced compost, compost mixes, and compost-like products are non-existent. What is available is aggregated to an extent that the data are not very helpful.
- Financial records that show exclusively the purchase of compost, or like soil amendments, by public and private entities are very difficult to acquire.
- Soil amendments for agricultural production or landscape use are typically a luxury purchase and thus susceptible to changing consumer purchasing power.

Despite these uncertainties some educated guesses can be made about compost markets on Oahu.

3.7.4.2 Imported Compost

In the early 1990s one estimate showed that 12,000 tons of compost and soil amendments (not including fertilizer) were brought into the entire state, not just Oahu (Hollyer et. al., 1996). The actually break down of the products that made up "soil amendments" is unknown. Using the calculations above, the 12,000 tons would equate to 24,000,000 lbs, or 30,000 cubic yards of compost, if in fact, it was all compost. To use up 30,000 cubic yards of media at 0.25 inches would require 882 acres.

Another estimate from the same time period showed that 688,630 "parcels of media" were imported to the entire State. If we assume that each parcel was 1.5 cubic feet of material (see **Table 3-14** below), that estimate would equate to 38,257 cubic yards of "media" (688,630 * 1.5/ 27 cubic feet in a cubic yard). It could be further assumed that since 80 percent of the population lives on Oahu, then 80 percent, or 30,606 cubic yards, of the media was used by Oahu consumers. Given the same depth of application, this material would cover 1,125 acres. The amount of land necessary to use up the compost, in both cases, would range from 9 to 11.5 percent of the acres that will be required to absorb all the composted green materials projected for Oahu.

In both cases the estimates and their interpretation are extremely subjective, but they are the best estimates of imports that can be found at this time. Even the US Army Corps of Engineers data for waterborne commerce for 1994, for example, only lists imports of 26,053 tons of "sand and gravel," and 4,951 tons of "soil and fill dirt" in their records. Further, a trip to a retail outlet will reveal the fact that there are many types of products that could be called soil amendments and their packages, or "parcels of media," range from a few cups to a number of cubic yards (see Table 3-14). Complicating this assessment even more is the fact that it is becoming very popular, and perhaps profitable, to add some compost to different planting media as a way to create more water retention or give it other desirable features. Said simply, an accurate assessment of the amount of compost imported into the state is very difficult.

Table 3-14
Compost Products Available At Retail Outlets (September 14, 1998)

Company	Location	Product	Volume	Price [1]
Imports				
Kellogg's	Carson, CA	Nitrohumus	1.5 cu ft	$12.49
		Growmulch	2.0 cu ft	$12.49
		Topper	2.0 cu ft	$12.49
		Flower/Veg/Garden Mix	2.0 cu ft	$12.49
Sun Gro	Bellevue, WA	Sunshine Peat Moss	1.0 cu ft	$9.99
Cascade Forest Products	Novato, CA	Organic Planting Mix (with compost)	2.0 cu ft	$11.99
		Gardener & Bloom Organic Compost	1.5 cu ft	$7.99
Hawaii Labeled Products (co–packed)				
Niu Nursery, Ltd.		Nui Organic Chicken Manure	.75 cu ft	$5.49
Made in Hawaii Products				
Hawaii Earth Products	Campbell Industrial Park	Menehune Magic Organic Soil Conditioner	1.5 cu ft	$6.99
Hawaii Earth Products	Campbell Industrial Park	Organic Compost for Lawn & Garden (with steer manure)	1.5 cu ft	$5.99
Maui Eko Systems, Inc.	Puunene, Maui	Clay buster (with compost)	1.5 cu ft	$9.99
		Lawn top–dressing (with compost)	1.5 cu ft	$10.99
		Premium Compost	1.5 cu ft	$9.99

1. This table is not necessarily to indicate price, since some of these products were on sale, but it is more to give an idea of the variety of bagged products on the market and their volumes.

3.7.5 How Much Compost is Produced on Oahu

Mainland imports, regardless of the imprecision of the data, are currently just part of the compost production and use on Oahu. According to Hawaii Department of Health records and other sources, there are two large green processing and compost sales operations on Oahu; Hawaiian Earth Products in Campbell Industrial Park and Kalaheo Green Waste Recycling Facility in Kalaheo. Smaller operations handling green materials include Hawaii Reserves Inc. in Laie and Unisyn BioWaste Conversion in Waimanalo (now closed). There are also military compost sites at Schofield Barracks, Hickam Air Force Base, Barbers Point, and Pearl Harbor Naval Shipyard. A recent compost study by Kimura International (1998) at Schofield Barracks indicated that they dispose of 5,280 tons of green materials annually, and if composted on-site and sold to the private sector, they could potentially generate sales of $104,550 (at $30/cubic yard). In addition, Maui Eko Systems Inc. of Puunene, Maui, has also penetrated the Oahu market with three compost-based products derived from biosolids and green trimmings.

What has allowed or encouraged this growth in local composting operations to occur? First, there was the interest in waste reduction across the United States started in the late 1980s and early 1990s. Then a number of Hawaii entrepreneurs, many of them whom are no longer in the compost business, saw an opportunity to provide a locally produced compost at a comparable price. At the same time, a green-trimmings partial ban at Oahu landfills and higher tipping fees at the landfills compared to compost facilities helped fuel the supply of materials to composters. Comparable quality was also of concern to buyers, and according to one study by Yogi, Hensley, and Hollyer (1997), the Hawaii-made composts that were compared against mainland-produced composts did as well or better in some instances.

The real driving force in the growth of the sales of quality locally-produced compost has been the availability of bulk quantities. In contrast to relatively expensive 1.5-cubic-foot bags of compost, larger users, such as landscapers, turf companies, golf courses, and construction projects, could now buy comparable local products at greatly reduced bulk prices. For example, if individual 1.5-cubic-foot bags of compost were wholesaled at $5.00 each (less than the lowest price shown in **Table 3-14**), it would cost $90 for one cubic yard. By contrast, a cubic yard of the same compost can be purchased for $25-$35, depending on the size of the order. This significant price differential for bulk material has been the major factor contributing to the growth of the market for compost and thus the success of commercial composting operations in the state. However without a significant difference in tipping fee between the composters and the disposal site, these operations might not be solvent.

Working with general information, the two largest commercial compost operations on Oahu are estimated to be processing about 115 raw tons per day, or 34,500 tons/year, based on a 300-day work year. Their potential capacity is estimated to be 490 raw tons per day, or 147,000 raw tons/year. Needless to say, these capacity figures are well below the maximum amount of green materials that could be collected on Oahu as part of this study; 266,000 tons/year.

It is estimated that the two major Oahu compost companies are producing in the neighborhood of 43,000 cubic yards of finished compost (and mulch) per year. This figure is comparable to the amount of all "soil media" and compost that was reported to be imported into the entire state in the early 1990s. To use all of this compost, at a depth of 0.25 inches, would require 1,260 acres. As shown in Table 3-12, there are enough acres of land on Oahu to absorb the current amount of compost that is being produced locally. And in fact, most of the commercial compost producers on Oahu and in the state are reporting at this time that they can sell all the quality product they can produce.

So now the question becomes, what if compost production increased from an estimated 43,000 cubic yards by factors of between 2 and 7.6 times, the latter being the uppermost boundary of production given a collection of 266,000 tons of raw material or 332,500 cubic yards of finished compost (and mulch)? While it appears that there are enough acres to absorb this amount of material, are there enough consumers or markets pay for it? As seen above, the City could probably take most of it, but if it cannot, what is the potential for expansion of commercial markets for compost? These markets, of course, would demand that the benefits outweigh the costs before they would purchase it.

3.7.6 Potential Markets for Compost

According to Tyler and Hollyer (1995), there are two types of markets, the "dollar" and "volume" markets, each one can be broken down into more discrete sub-markets **(Table 3-15)**. The former indicates a low volume usage but a higher ability or willingness to pay for compost. By contrast, the volume market is willing to absorb a great deal of compost, but not willing or able to pay very much for it.

Table 3-15
The Volume and Dollar Markets for Compost

Dollar Market	Volume Market
Retail market/homeowners	Landfill daily cover
Sport turf applications	DOTs and DNRs
Landscapers, grounds maintenance, garden centers	Silviculture
Nurseries, floriculture	Sod Production
Topsoil blenders	Agriculture

Compost is a wonderful natural product. Fertilizers, organically or synthetically derived, by contrast, don't have this list of benefits. But then again, compost is typically not a fertilizer either, as it is usually rather low in the macro nutrients of nitrogen, potassium, and phosphorous. It appears that from a commercial production or even from a home gardener's standpoint, there could be room, and need, for both products. But can the value of the benefits of compost outweigh the costs? The answer to this question is important to know so that some estimate of projected compost sales, and thus use of all the composting that could be created, can be derived. To get an idea of the potential, look at the motivation behind a commercial farming operation and that of someone wanting to create an attractive landscape. The first case is an example of a high volume but low revenue purchaser, and the second is the opposite, low volume but high revenue.

3.7.6.1 Commercial Farming

There is little doubt from Table 3-12 that the amount of land listed as "agriculture" for Oahu could easily absorb all the compost that could be produced. If a commercial grower would use compost, they would typically get most if not all the benefits listed on Table 3-15, including reductions in water use, agricultural chemicals, and soil erosion, and potentially an increase in yield. But most fruit and vegetable growers' financial "margins" are a bit "thin." In other words, they need to watch their spending on inputs relative to what they will get when they sell their crop. It is not all that uncommon for a producer to loose money on a crop if the yields are low and the costs high.

To get an example of how one could estimate the benefits and costs of a compost application, here is an example of someone who grows two four-month crops on one acre of land in a one-year period. The field will be fallowed for the remaining four months. The grower applies one 0.25 inch treatment of compost before planting the first crop and expects the benefits of that one treatment to be generally equal between the two successive crops. (While there is no doubt this example is crop, location, soil, weather, and grower-specific, the general premise and thinking is universal.) The analysis starts with an estimation of what it costs to buy the compost and have it delivered and incorporated. An example of how a savings in water might be estimated from using compost will follow. The benefits of using compost on other cost areas will be discussed briefly. Note that the potential benefits are defined by quantitative and qualitative measures. Both of these measurements are necessary, even though the quantitative would be most desirable, because there is little current empirical data on the cost of production of 4-month field crops in Hawaii or on the actual benefits of applying compost to a field crop. While we do not have empirical data, this example illustrates the data needed to make the calculation.

Table 3-16
The Costs and Benefits of Compost Use
Under Some Generic Conditions

Cost of compost delivery, spreading and incorporation over one acre	
Assumptions	
Inches of compost to be applied	0.25
Number of applications per year	One
Number of square feet/acre	43,560
Cubic yards of compost to be applied (square feet x depth of inches x 0.0031 = cubic yards)	34
Bulk cost of compost ($30/cubic yard)	$1,020
Delivery charge ($3/cubic yard)	$102
Estimated cost to spread & incorporate compost ($4/cubic yard)	$136
Total cost for delivered compost, spreading and incorporation	$1,258
Benefits of compost delivery, spreading and incorporation over one acre	
Water Use	
Daily waste use (assume plants need 0.25 inches/day) 1 acre–inch=27,154 gallons/0.25 acre–inch/day)	6,789 gallons/day
Total amount of water used at end of each 30–day month	203,655 gallons
Oahu Board of Water Supply rates 1998: *Block 1, first 13,000 gallons, $2 for each 1,000 gallon unit per month* *Block 2, over 13,000 gallons, $.77 for each 1,000 gallon unit per month*	$172.80/month
Inches of compost to be applied	0.25
Number of applications per year	One
Number of square feet/acre	43,560
Cubic yards of compost to be applied (square feet x depth of inches x 0.0031 = cubic yards)	34
Bulk cost of compost ($30/cubic yard)	$1,020

Benefits of compost delivery, spreading and incorporation over one acre	
Water Use	
Amount of monthly water bill (204 one-thousand gallon units) *Block 1 water cost: (13 one thousand gallon units * $2/unit)* *Block 2 water cost: (190 one thousand gallon units * $.77/ unit)*	$172 $26 $146
Total water bill for 8 months (8 x $172)	$1,378
If compost can save 10 percent on water bill, savings equals	$138

In reviewing this table it is possible to see general costs of inputs and make some assumptions about what financial effect compost might have on a commercial vegetable operation. In the case of water for instance, a $1,258 investment in compost might yield a savings of $138 in water (based on an assumption of 10 percent). Here are some other potential savings.

Chemical Usage

The reduction in the use of agricultural chemicals as a result of the use of compost is hard to estimate. Nonetheless, there is a growing number of studies that indicate that with healthier soil, the clear result of amending the soil with compost, plants are healthier. With healthier plants it is assumed that there can be a reduction in the use of agricultural chemicals. If this grower grows a crop organically, there would be no additional savings from the reduction in pest control chemicals. If, however, the grower used, say $150 per acre of pest control chemicals of all types, including the application costs, and compost allowed the grower to cut the use by say 20%, then the grower would save $30. If they used more chemicals, the savings could be greater.

Soil Erosion

There is little doubt that compost can help maintain and even build up soils. Yet there seems to be no financial accounting for the loss of topsoil due to run-off, the decreased health of the soil because much of the organic materials have been washed away, or the resulting impacts of this pollution on the beauty and productivity of our surface water system. It can be foreseen that a grower could save a few hundred dollars in soil replacement costs. However, once the soil was stabilized and the run-off under control, the savings would not necessarily be applicable to each cycle of compost use.

Fertilization

Compost is not typically considered a fertilizer or at the very least as a significant source of the macro nutrients: nitrogen, phosphorus and potassium. It is, however, a good source of the micro nutrients which are starting to be more recognized as important for growth. As it relates to fertilizers, what compost does best is hold macronutrients in the soil longer and release them at a slower rate. This can ultimately result in a decreased need for some fertilizer. If, say, two 4-month crops of tomatoes needed about 750 pounds of a complete fertilizer each, for instance 15-15-15, it would cost $311 for this 3/4 ton of material. If compost allowed for 10 percent reduction in this cost, there would be a savings during the 8 months of $31. If the compost allowed for a greater reduction in fertilizer use, the savings would be greater.

Increased Yields

Healthier plants produce more, and what they produce may taste better and have a longer shelf life. These are the general conclusions coming out of recent studies on crop production using compost. Yet, it is difficult to estimate the value of an increase in yield and improved quality. The grower would need to know the market well to understand that the increased yield justified the cost of the compost. They would have to track the market to be able to see a potential oversupply situation and a price drop that could make the compost application less appealing.

Overall, it is difficult to justify the cost of compost to a large-scale grower, at least given its current price and the lack of available data on which to base better production decisions. In the example summarized in Table 3-16, we had $1,258 dollars of cost for compost and a few hundred dollars of benefits. It is obvious, at least for this example, that the margin between fairly firm costs and the benefit "values" does not make a strong case for the current use of compost on a commercial fruit or vegetable farm. The costs include the use rate and the cost of the compost and its delivery and incorporation. Yet, modifications in this scenario could be made that would justify the cost of using compost. These modifications could include:

- The cost of compost could be subsidized.
- Use 0.125 inches of compost rather than 0.25 inches, cutting the cost in half. (There is some evidence to suggest that even a dusting of compost does have some positive benefits.)
- Using less depth or the same amount of compost but only on the rows and not between rows, thus again halving the cost.
- Growers could be charged for the damage caused by runoff of chemicals and soil from their land.

- The price of water could be increased to encourage conservation.

The bottom line is that justifying the benefits of use to a commercial volume buyer is a case-by-case situation. Therefore, it is not appropriate to assume that the City wants to keep green trimmings out of H–POWER and the landfill and somehow commercial agricultural producers will automatically find using compost is a good business decision and buy all the compost produced.

3.7.6.2 Commercial and Home Landscape Development and Maintenance, a Dollar Market

In contrast to what is often referred to as a "volume market," i.e., large volume but low willingness or ability to pay, a "dollar market" is one where less compost would be purchased, but the cost is not as critical to the buyer. The compost is not necessarily going into the production of a market commodity or moderately valued consumable agriculture product, or the maintenance of a public good, like a roadside or park. Or if it is used by an agricultural producer, it is generally on a smaller scale or applied most judiciously to maximize the benefits relative to the costs.

To illustrate the use of compost in a dollar market, examples of home and hotel landscapes will be explored. Homeowners have few qualms about paying $6-12.50 for one 1-2 cubic foot bag of compost, or for that matter, a half dozen bags (about a third of a cubic yard) that could cost them $36-75, even though they could pick up an entire cubic yard for $30-35 or have it delivered for a few dollars more. This is because their lawns and gardens are not generally thought of as a production site (farm) that requires that the inputs must be paid back by outputs. Further, bags of compost can be maneuvered more easily and stored for a longer period than a pile of compost in the middle of the driveway. Home gardens and lawns are to most people a place of enjoyment, and they are willing to spend money, and in some cases a lot of money, year after year for that enjoyment. This market in Hawaii was once the exclusive domain of products coming from Kellogg or other similar mainland companies that sold compost in bags. Today, companies like Hawaiian Earth Products are equipped with baggers that allow them to compete, at almost half the price for a bagged product, with the mainland products. They also have product in bulk, which gives their customers volume and price alternatives.

As for growth in this market segment for Hawaii companies, it will come in two places: by replacing the imported compost and from marketing efforts to increase the number of homeowners who use Hawaii-made compost. If all the 280,887 single and multifamily dwellings on Oahu (1994 figures from DBEDT, 1995, not including structures on military bases) used just two 1.5 cubic foot bags of compost (1/9 of a cubic yard) per year, then there would be a market for 31,210 cubic yards of compost (or mulch), or about one tenth of what could be produced by collecting 266,000 tons of raw green materials. At 0.25 inches, these two 1.5 cubic foot bags would only cover an area of 24 feet by 24 feet. Many people have gardens and lawns that exceed this amount of space and so initial and increased sales would be a function of affordable, actual (or perceived) benefit, and increased consumer awareness.

A hotel or golf course landscape is another example of a dollar market, since the use of compost would be more confined and the results, i.e., a beautiful landscape or turf area, have more of a dollar impact than would be seen with production agriculture. There were 693 visitor accommodation properties and 72 golf courses in Hawaii in 1994 (DBEDT, 1995). Two hundred one of these visitor properties and 35 golf courses are on Oahu. From Table 3-11 we see that hotel properties occupy 319 acres, though it is unclear if this land area includes the footprint of the buildings and parking lots. It is unlikely that 319 acres would also include the acreage of an attached golf course, since the average 18-hole golf course in the state is about 157 acres, and 30 of 35 golf courses on Oahu are 18 holes (Cox, Hollyer, Schug; DBEDT, 1997). Assuming that only half of the 319 "hotel" acres, or 160 acres, are landscaped acres and if we assume that there are 4,285 acres in the non-City golf courses, then if they used only a yearly top-dressing of 0.25 inches, potentially there is a market for 151,130 cubic yards of compost on 4,445 acres (4,445 acres x 34 cubic yards/acre). Again, initial and increased sales would be a function of affordable, actual (or perceived) benefit, and increased landscaper awareness.

3.7.7 Summary

Collecting green trimmings and turning them into compost has both benefits and costs. The City manages enough land area to make use of most of the potential compost that could be produced locally for years to come. Using compost to enhance soil, however, would require paying millions of dollars to commercial processors for the finished compost. Yet, these costs could potentially be off-set by adjusting tipping fees and by the benefits derived by keeping green materials out of H–POWER and landfills, and by creating healthier soils, cleaner waterways, and more attractive, durable landscapes in its parks and along its roadways.

There are also other markets for compost derived from Oahu's green trimmings. These include state and federal agencies as well as private sector markets, including farms and commercial and home landscapes. Between the potential use by the City and the number of other acres of land available that could use an annual application of compost, it is clear that all the compost produced on Oahu could be used. The question is how to ensure that the collection and processing of green materials does not outpace the rate at which the resulting compost can be sold and distributed, even at a zero cost. If the entire burden for success of green recycling and compost use is placed exclusively on commercial and home buyers' willingness to pay for the hundreds of thousands of cubic yards of compost that could be produced, at $25-30 per cubic yard, then there will be great quantities of raw green trimmings and finished compost that will pile up at commercial compost sites. However, if the City decided that they would invest in this system of recycling and reuse of green materials for the larger good of the Island, then there could be a systematic and balanced use of compost. In order for the City to begin using compost in large enough quantities to stave off massive stockpiling, it would probably need to mandate the use of compost throughout the system and train City design, installation, maintenance crews in the proper use of compost.

SECTION 4

RECOMMENDATIONS

4.1 CURBSIDE COLLECTION

Curbside collection of green waste has been offered by the City to residents with automated rubbish collection for some time. This report evaluated the expansion of that program to all of the households that have City collection services. It would also increase the frequency of collection from monthly to twice monthly.

The amount of waste produced in most of the collection districts justifies the expanded collection frequency. There are some collection districts where the amount of green waste may not result in the most cost-effective program. However, it is widely believed that there is a pressing need to divert materials from disposal to conserve limited landfill capacity.

The diversion of green waste will conserve disposal capacity, but not on a unit-for-unit basis. Residential City-collected green waste is taken to H–POWER, so only the ash from combustion is taken to the landfill. The ash is about 10 percent of the incoming volume of waste, so the conservation of landfill capacity is only 10 percent of the volume of green waste handled.

Removing green waste from H–POWER will have a negative effect on the amount of material that facility handles. The benefit to the City of processing more material through H–POWER is in the extra electricity generated, reducing importation of oil and re–using a waste material. By reducing disposal of green waste in H–POWER, the electricity benefit is also reduced.

H–POWER is now seeing a reduction in the amount of waste that is brought to it for processing, most likely due to the generally depressed economy in the city. Other areas nationwide have observed that waste generation tracks economic activity. As such, the City should expect that the amount of material removed from H–POWER by green waste diversion will be replaced by other materials when the economy improves.

Diversion of green waste through an expanded curbside collection system will be more costly for the ratepayer than the current system. It will result in a greater amount of high quality compost being produced on the island from local material.

We recommend that the City expand a curbside green waste collection program.

4.2 CENTRALIZED PROCESSING/TRANSFER SITE

The two existing major processing facilities have sufficient capacity to process all of the waste expected in an expanded City curbside collection program, the current City monthly collections, the current commercial green waste that is now diverted, and the commercial green waste that could be collected from that which is disposed. In addition to the current processing options, the City is considering a sewage sludge composting facility to divert sludge from landfill disposal. That process will need green waste as a bulking agent. The current and expected processing capacity can handle all of the green material expected to be diverted.

Because the two existing processing facilities are located at either end of the island, the transportation time from the downtown area could encourage illegal dumping rather than disposal at a processing facility. As such, there is a need for a centralized processing/transfer facility to consolidate loads and transport them to one of the processing facilities. The site for such a facility could be near Middle Street, where the City's Keehi Transfer Station is located, or on Sand Island. There is no space at the Keehi site, but there may be a suitable site in the surrounding area. There may be sites at Sand Island given the industrial nature of the area. The problems of getting a long-term lease on land in both areas will add to the difficulty of siting a facility.

The type of facility suggested would accept waste materials from commercial and residential customers. The material would be ground to produce a mulch and a compostable fraction. The mulch could be sold or given to the public. The compostable fraction would be transported to a composting site. The facility would conserve on transportation costs and provide a product to the public.

For this facility to be financially viable, the cost of transportation and processing has to be less than the tip fee at the composting site plus the customer's transportation cost. The best way for the City to determine if a facility would be financially viable would be to issue a request for proposals. In the request, the City would need to agree to supply a specified amount of green waste to the facility and the contractor would provide the site, equipment, labor, and transportation for the waste.

We recommend the City issue a Request for Proposals for a centralized processing/transfer site.

4.3 MARKETING

The marketing of compost is one of the most important aspects of producing the material. There is extensive research and a long history of use of compost that shows it improves soil characteristics. The value of compost is not always understood by the potential users. Without a market to purchase the product, the cost of producing compost and mulch needs to be paid by the processing fee. In most markets, including those in Oahu, the revenue from processing does not support the total cost of producing the compost.

With the addition of the material from an expanded City collection program, the amount of compost that needs to be marketed will increase dramatically. It is possible that the current processors will not be able to expand their markets to accommodate the additional material, particularly if the City rapidly expands its collection program. There could be a large oversupply of compost, forcing a reduction in the price of product. Doing so will reduce the perceived value of the product.

As summarized in the discussion of marketing, the City & County departments with landscaping responsibility could be a major bulk user of compost and mulch. It can be difficult to convince departments to use the material, although those that have (e.g., the City Zoo and the Parks Department) have had good results. The reluctance of some City staff has prevented use of compost. The City should have a policy directing the use of recycled materials where the price does not exceed a specified amount greater than a non-recycled product. A policy requiring the use of compost produced from material the City collects would be a viable way for the City to support this program.

We recommend that the City establish a policy directing its departments to use compost in applications where it has been shown to have beneficial results on plant life and soil health.

REFERENCES

1. Franklin Associates , "Solid Waste Management at the Cross Road," December 1997.

2. Ecodata, "Recycling and Yard Debris Collection: State of the Industry," December 1997.

Appendix A

COST ESTIMATE CALCULATIONS

Table A-1

Assumptions

This table is a listing of the major assumptions made in analyzing the cost of collection. Many of the assumptions are listed in the report body (Table 2-1), and are not repeated here.

Collection District Data

District	Number of Households	Tons Residential Waste per Year	Percent Green Waste	Tons of Green Waste/Year
Honolulu	56,736	124,210	29.5%	36,642
Ewa	36,125	68,449	23.8%	16,291
Koolaupoko	25,428	49,127	35.7%	17,538
Wahaiwa	14,047	22,247	24.3%	5,406
Waianae	9,220	16,001	27.3%	4,368
Waialua *	3,848	8,769	24.3%	2,129
Koolauloa *	4,762	6,266	24.3%	1,523

* The composition of the waste in the Waialua and Koolauloa districts was not assessed. We used the percentage green waste from the Wahaiwa district for those two districts.

Equipment Costs

Item	Cost	Useful Life (Years)
Rear loading truck	$158,000	8
Automated truck	$240,000	6
Front loader with claw	$175,000	8
96 gallon container	$65	10

Labor Costs

Category	Annual Salary	Benefit Rate	Total Annual Cost
Laborer	$23,388	58.21%	$37,002
Loader operator	$26,916	58.21%	$42,584
Manual truck operator	$26,916	58.21%	$42,584
Automated truck operator	$27,946	58.21%	$44,217

Table A-2

Cost of Collection in the Honolulu Collection District

25 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$76.11	$0.99	$136.12	$1.78	$75.40	$0.98
Bi–weekly	$112.21	$1.47	$171.63	$2.24	$110.97	$1.45
Weekly	$130.27	$1.70	$207.14	$2.71	$181.58	$2.37

50 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$58.05	$1.52	$88.06	$2.30	$75.40	$1.97
Bi–weekly	$76.11	$1.99	$105.82	$2.76	$75.40	$1.97
Weekly	$94.16	$2.46	$129.49	$3.38	$101.94	$2.66

75 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$58.05	$2.27	$75.99	$2.98	$69.50	$2.72
Bi–weekly	$64.07	$2.51	$83.88	$3.29	$69.50	$2.72
Weekly	$76.11	$2.98	$95.71	$3.75	$87.19	$3.42

Table A-3

Cost of Collection in the Ewa Collection District

25 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$82.59	$0.72	$186.91	$1.62	$123.01	$1.07
Bi–weekly	$125.19	$1.09	$214.84	$1.87	$207.02	$1.80
Weekly	$167.78	$1.46	$298.61	$2.60	$207.02	$1.80

50 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$58.05	$1.52	$113.46	$1.97	$81.76	$1.42
Bi–weekly	$82.59	$1.44	$127.42	$2.22	$102.63	$1.78
Weekly	$103.89	$1.81	$169.31	$2.94	$144.39	$2.51

75 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$54.20	$1.41	$88.97	$2.32	$81.76	$2.13
Bi–weekly	$68.40	$1.78	$107.59	$2.81	$81.76	$2.13
Weekly	$82.59	$2.15	$126.20	$3.29	$109.59	$2.86

Table A-4

Cost of Collection in the Koolaupoko Collection District

25 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$76.62	$1.10	$119.11	$1.71	$75.90	$1.09
Bi–weekly	$113.23	$1.63	$167.12	$2.40	$111.79	$1.61
Weekly	$149.85	$2.15	$191.13	$2.75	$147.69	$2.12

50 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$58.31	$1.68	$79.55	$2.29	$75.90	$2.18
Bi–weekly	$76.62	$2.20	$91.56	$2.63	$75.90	$2.18
Weekly	$94.93	$2.73	$115.56	$3.32	$93.84	$2.70

75 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$52.21	$2.25	$66.37	$2.86	$75.90	$3.27
Bi–weekly	$64.41	$2.78	$82.37	$3.55	$75.90	$3.27
Weekly	$76.62	$3.30	$90.38	$3.90	$75.90	$3.27

Table A-5

Cost of Collection in the Wahaiwa Collection District

25 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$169.35	$1.25	$232.33	$1.71	$166.80	$1.23
Bi–weekly	$169.35	$1.25	$317.13	$2.33	$166.80	$1.23
Weekly	$298.69	$2.20	$317.13	$2.33	$293.60	$2.16

50 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$104.67	$1.54	$136.16	2. 01	$103.40	$1.52
Bi–weekly	$104.67	$1.54	$178.56	$2.63	$103.40	$1.52
Weekly	$169.35	$2.49	$220.96	$3.25	$166.80	$2.46

75 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$83.12	$1.84	$104.11	$2.30	$82.27	$1.82
Bi–weekly	$83.12	$1.84	$132.38	$2.92	$82.27	$1.82
Weekly	$126.23	$2.79	$160.64	$3.55	$124.53	$2.75

Table A-6

Cost of Collection in the Waianae Collection District

25 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$199.77	$1.81	$231.93	$2.11	$196.63	$1.79
Bi–weekly	$199.77	$1.81	$231.93	$2.11	$196.63	$1.79
Weekly	$199.77	$1.81	$336.68	$3.06	$196.63	$1.79

50 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$119.89	$2.18	$135.96	$2.47	$118.31	$2.15
Bi–weekly	$119.89	$2.18	$135.96	$2.47	$118.31	$2.15
Weekly	$119.89	$2.18	$188.34	$3.42	$196.63	$3.57

75 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$93.26	$2.54	$103.98	$2.83	$92.21	$2.51
Bi–weekly	$93.26	$2.54	$103.98	$2.83	$92.21	$2.51
Weekly	$93.26	$2.54	$138.89	$3.78	$144.42	$3.93

Table A-7

Cost of Collection in the Waialua Collection District

25 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$403.90	$3.86	$361.45	$3.45	$396.73	$3.79
Bi–weekly	$403.90	$3.86	$361.45	$3.45	$396.73	$3.79
Weekly	$403.90	$3.86	$361.45	$3.45	$396.73	$3.79

50 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$221.95	$4.24	$200.72	$3.84	$218.37	$4.17
Bi–weekly	$221.95	$4.24	$200.72	$3.84	$218.37	$4.17
Weekly	$221.95	$4.24	$200.72	$3.84	$218.37	$4.17

75 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$161.30	$4.62	$147.15	$4.22	$158.91	$4.55
Bi–weekly	$161.30	$4.62	$147.15	$4.22	$158.91	$4.55
Weekly	$161.30	$4.62	$147.15	$4.22	$158.91	$4.55

Table A-8

Cost of Collection in the Koolauloa Collection District

25 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$300.21	$3.23	$284.24	$3.06	$295.08	$3.17
Bi–weekly	$300.21	$3.23	$284.24	$3.06	$295.08	$3.17
Weekly	$300.21	$3.23	$454.83	$4.89	$295.08	$3.17

50 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$170.10	$3.66	$162.12	$3.49	$167.54	$3.60
Bi–weekly	$170.10	$3.66	$162.12	$3.49	$167.54	$3.60
Weekly	$170.10	$3.66	$247.42	$5.32	$167.54	$3.60

75 Percent Recovery

Collection Frequency	Collection Method					
	Claw		Automated		Manual	
	$/ton	$/HH/Mo	$/ton	$/HH/Mo	$/ton	$/HH/Mo
Monthly	$126.74	$4.09	$121.41	$3.92	$125.03	$4.03
Bi–weekly	$126.74	$4.09	$121.41	$3.92	$125.03	$4.03
Weekly	$126.74	$4.09	$121.41	$3.92	$125.03	$4.03